

AMENDMENTS TO THE SPECIFICATION

Please amend the specification as follows. Insertions are shown underlined while deletions are ~~struck through~~.

Paragraph beginning at page 4, line 19 of the specification:

Japanese Unexamined Patent Publication No. 1992-368778 shows that it is possible to prevent carbon from being broken by forming a double structure in which a carbon particle having a high crystallinity is covered with carbon having a low crystallinity. When using carbon prepared by the above method as an active material, it is theoretically possible to obtain an electrode superior in potential smoothness and having a large capacity by preventing decomposition of an electrolyte. When attempting formation of a practical electrode by using the double-structure active-material particles, an electrode having a thickness of 50 to 500 μm for a cylindrical battery by applying an active material onto copper foil. However, the capacity per electrode volume was not increased because the electrode density was not easily raised. More specifically, it is difficult to raise the electrode density. If setting the electrode density to 1.20 g/cm^3 or more through pressure compression, a high volume capacity of 400 mAh/cm^3 or more of the negative electrode cannot be resultantly obtained because the double-structure active material particles are broken.

Paragraph beginning at page 8, line 19 of the specification:

Particularly, in the case of a flat battery, when using the method of pressing wound electrodes, a short circuit occurs due to separation of an electrode active-material layer from a current ~~current~~ collector at an electrode portion having a intensively pressed curvature. When using a baggy separator, sufficient pressure cannot be obtained because of a large electrode area. Therefore, a gap is easily formed between a separator and an electrode layer due to creases or the like of the separator, and the internal resistance of the battery easily increases. Moreover, the binding margin of the separator increases in size and the packing efficiency of the electrodes decreases, influencing the capacity design of the battery. In view of the above-described points, a stacking method realizing a high packing efficiency of electrodes is not found which is suitable for a large scale battery or a flat large scale battery, simplifies positioning of layers, and hardly causes a short circuit.

Paragraph beginning at page 12, line 21 of the specification:

Negative electrode formed by using graphite having an average particle diameter of 1 to 50 μm as active-material particles, a resin as a binder, and a metal as a current collector and having a porosity of 20 to 35%, an electrode density of 1.40 to 1.70 g/cm^3 , and an capacity of electrode of 400 mAh/cm^3 or higher.

Paragraph beginning at page 12, line 21 of the specification:

The positive-electrode current collector of each positive electrode 101a is electrically connected to a positive-electrode tab 3 via a positive-electrode tab 103a and similarly, negative-electrode current collectors of the each negative electrodes 101b and 101c are electrically connected to a negative-electrode ~~electrode~~ tab 4 via a negative-electrode tab 103b. The positive-electrode tab 3 and negative-electrode ~~electrode~~ tab 4 are mounted on the battery case, that is, the upper case 1 while insulated therefrom. The entire circumferences of the upper case 1 and the bottom case 2 are welded at the point A shown by the enlarged view in FIG. 1. The upper case 1 is provided with a safety vent 5 for releasing the internal pressure in the battery when the pressure rises. The non-aqueous secondary battery shown in FIGS. 1 and 2 has, for example, a length of 300 mm, a width of 210 mm, and a thickness of 6 mm. A lithium secondary battery using LiMn_2O_4 for the positive electrode 101a and graphite described below for the negative electrodes 101b and 101c has, for example, an energy capacity of 80 to 100 Wh and it can be used for a energy storage system.

Paragraph beginning at page 23, line 24 of the specification:

(1) A mixture slurry for a positive-electrode was obtained by mixing 100 parts by weight of spinel-type LiMn_2O_4 (made by SEIMI CHEMICAL; product No. M063), 10 parts by weight of acetylene black, and 5 parts by weight of polyvinylidene fluoride (PVdF) with 100 parts by weight of N-methylpyrrolidone (NMP). The slurry was applied to the both sides of an aluminum foil having a thickness of 20 μm and dried and then, pressed to obtain a positive electrode. FIG. 5 is an illustration of an electrode. In the case of this embodiment, the coating area ($W1 \times$

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W2) of an electrode (101) is $268 \times 178 \text{ mm}^2$ and slurry is applied to the both sides of a $20 \text{ }\mu\text{m}$ aluminum foil (102) at a thickness of $120 \text{ }\mu\text{m}$. As a result, the electrode thickness t is $260 \text{ }\mu\text{m}$. One of the edge portions of the current collector extending along the arrow W2 and having a width of 1 cm is not coated with the electrode, and a tab 103 (aluminum having a thickness of 0.1 mm and a width of 6 mm) is welded thereto.

Paragraph beginning at page 24, line 11 of the specification:

(2) A mixture slurry for a negative-electrode was obtained by mixing 100 parts by weight of graphitized mesocarbon microbeads (MCMB: made by OSAKA GAS CHEMICAL Co., Ltd.; product No. 6 28) and 10 parts by weight of PVdF with 90 parts by weight of NMP. The slurry was applied to the both sides of a copper foil having a thickness of $14 \text{ }\mu\text{m}$ and dried, and then pressed to obtain a negative electrode. Because the shape of the negative electrode is the same as the above positive electrode, the negative electrode is described by referring to FIG. 5. In the case of this embodiment, the coating area ($W1 \times W2$) of the electrode (101) is $270 \times 180 \text{ mm}^2$ and the slurry is applied to both sides of the copper foil (102) at a thickness of $80 \text{ }\mu\text{m}$. As a result, the electrode thickness t is $174 \text{ }\mu\text{m}$. One of the edge portions of the current collector extending along the arrow W2 and having a width of 1 cm is not coated with the electrode, and a tab 103 (nickel having a thickness of 0.1 mm and a width of 6 mm) is welded thereto.

Paragraph beginning at page 24, line 29 of the specification:

Moreover, the slurry was applied to only one side by the same method and a single-sided electrode having a thickness of $94 \text{ }\mu\text{m}$ was formed by the same method except for the application of the slurry. The single-sided electrode is positioned at the outermost side in the stacked electrodes which is described in the following Item (3) (101c in FIG. 6).

Paragraph beginning at page 26, line 19 of the specification:

(1) A battery was constituted similarly to the case of the above embodiment except for ~~changing~~changing electrode sizes, numbers of electrodes to be stacked, and battery sizes. In

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Table 1, the electrode size denotes the size of the negative electrode. The size of the positive electrode is 2 mm smaller than the negative electrode size in each side. The number of electrodes to be stacked denotes the number of positive electrodes. The number of negative electrodes is one more than the number of positive electrodes as described for the embodiment 1-1, in which two single-side-coated electrodes are included.

Paragraph beginning at page 29, line 3 of the specification:

The particle diameter of the above graphite is preferably 1 to 50 μm , more preferably 3 to 40 μm , or still more preferably 5 to 35 μm . If the particle diameter is less than 1 μm , it is impossible to raise the electrode density. However, if the particle diameter exceeds 50 μm , a large capacity cannot be obtained because the graphite is broken when an electrode having a small thickness of approximately 100 μm is pressed to raise the electrode density.

Paragraph beginning at page 30, line 24 of the specification:

In this embodiment, as a metal for the current collector copper foil, stainless-steel foil, or titanium foil can be used without limitation thereto. Moreover, it is possible to use materials allowing an electrode to be formed on metallic foil or between metallic materials, such as expand metal or mesh material. Among these materials, it is more preferable to use a copper foil having a thickness of 1 to 50 μm because it allows a negative electrode to be easily formed by a coating method to be mentioned later and is superior in strength and electric resistance.

Paragraph beginning at page 31, line 12 of the specification:

First, a slurry is prepared by uniformly dissolving graphite in a binder-resin solution obtained by dissolving polyvinylidene fluoride (PVdF) in N-methylpyrrolidone. In this case, it is also possible to add a conductive material such as acetylene black or binder assistant such as polyvinyl pyrrolidone. Then, the obtained slurry is applied onto copper foil by a coater and dried, and an electrode layer is formed on the copper foil, and then pressed to obtain a negative

electrode for the non-aqueous secondary battery, which has a thickness of 50 to 500 μm . The electrode layer is formed on both sides or either side of the copper foil according to necessity.

Paragraph beginning at page 33, line 30 of the specification:

The diameter of a double-structure active-material particle comprising the above graphite-based particle and its covering layer is preferably 1 to 50 μm , more preferably 3 to 40 μm , and still more preferably 5 to 35 μm . When the particle diameter of the double-structure body is less than 1 μm , it is impossible to improve the electrode density. When the particle diameter exceeds 50 μm , a large capacity cannot be obtained because a double-structure active-material particle is broken when an electrode having a small thickness of 100 μm is pressed to raise an electrode density.

Paragraph beginning at page 35, line 22 of the specification:

In this embodiment, as a metal for current collector a copper foil, stainless-steel foil, or titanium foil can be used without limitation thereto. Moreover, it is possible to use materials allowing an electrode to be formed on a metallic foil or between metallic materials, such as expand metal or steel. Among these materials, it is more preferable to use a copper foil having a thickness of 1 to 50 μm because it allows a negative electrode to be easily formed by a coating method to be mentioned later and is superior in strength and electric resistance.

Paragraph beginning at page 36, line 9 of the specification:

First, a slurry is prepared by uniformly dissolving double-structure active-material particles in a binder-resin solution obtained by dissolving polyvinylidene fluoride (PVdF) in N-methylpyrrolidone. In this case, it is also possible to add a conductive material such as acetylene black or binder assistant such as polyvinyl pyrrolidone. Then, the obtained slurry is applied onto a copper foil by a coater and dried, and an electrode layer is formed on the copper foil, and then pressed to obtain a negative electrode for the non-aqueous secondary battery, which

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has a thickness of 50 to 500 μm . The electrode layer is formed on both sides or either side of the copper foil according to necessity.

Paragraph beginning at page 44, line 8 of the specification:

The particle diameter of coating graphite used as a negative-electrode active material in this embodiment is normally 1 to 50 μm , more preferably 3 to 40 μm , and still more preferably 5 to 35 μm . When the particle diameter of the coating graphite is too small, it is impossible to raise an electrode density. However, when the particle diameter is too large, a large capacity is not obtained because covering-graphite particles are broken when performing pressing to raise an electrode density in order to manufacture a thin electrode having a thickness of approximately 100 μm .

Paragraph beginning at page 45, line 28 of the specification:

In this embodiment, as a metal used as a current collector a copper foil, stainless-steel foil, or titanium foil can be used without limitation thereto. It is possible to use a metal allowing an electrode to be formed on metallic foil or between metal materials such as expand metal or steel. Among them, copper foil having a thickness of 1 to 50 μm is more preferable because the foil allows a negative electrode to be easily manufactured in accordance with the coating method to be described later and is superior in strength and electric resistance.

Paragraph beginning at page 46, line 15 of the specification:

First, a slurry is prepared by uniformly dissolving coating graphite in a binder-resin solution obtained by dissolving polyvinylidene fluoride (PVdF) in N-methylpyrrolidone. In this stage, it is also possible to add a conductive material such as acetylene black or binder assistant such as polyvinyl pyrrolidone. Then, the obtained slurry is applied onto copper foil by a coater and dried, and an electrode layer is formed on the copper foil, and then pressed to obtain a negative electrode having a thickness of 50 to 500 μm for the non-aqueous secondary battery. The electrode layer is formed on both sides or either side of the copper foil according to necessity.

Paragraph beginning at page 48, line 3 of the specification:

(1) A positive-electrode mixture slurry was obtained by mixing 100 parts by weight of spinel-type LiMn_2O_4 (made by SEIMI CHEMICAL, product No. M063), 10 parts by weight of acetylene black, and 5 parts by weight of polyvinylidene fluoride (PVdF) with 100 parts by weight of N-methylpyrrolidone (NMP). A positive electrode was obtained by applying the slurry to both sides of aluminum foil having a thickness of 20 μm and serving as a current collector, and by drying and pressing the foil. FIG. 6 is an illustration of an electrode. In the case of this embodiment, the coating area ($W1 \times W2$) of an electrode 101 was $268 \times 178 \text{ mm}^2$ and the slurry was applied to both sides of a current collector 102 of 20 μm thickness at a thickness of 128 μm . As a result, the electrode thickness t was 276 μm . One of the edge portions of the shorter side of the current collector 102 was not coated in 1 cm width and a tab 103 (aluminum with a thickness of 0.1 mm and a width of 6 mm) was welded.

Paragraph beginning at page 48, line 23 of the specification:

(2) A negative-electrode slurry was obtained by mixing 100 parts by weight of graphitized mesocarbon microbeads (MCMB, made by OSAKA GAS CHEMICAL, product No. 6-28) and 10 parts by weight of PVdF with 90 parts by weight of NMP. A negative electrode was obtained by applying the slurry to both sides of a copper foil having a thickness of 14 μm and serving as a current collector, and by drying and then pressing the foil. Before pressing the foil, 4.3% of NMP was left in the electrode. The electrode density was 1.58 g/cm^3 , and previous evaluation of the capacity of electrode of the electrode was 430 mAh/cm^3 . Because the shape of the electrode was the same as that of the above-described positive electrode, the negative electrode is described below with reference to FIG. 6. In the case of this embodiment, the coating area ($W1 \times W2$) of the electrode 101 was $270 \times 180 \text{ mm}^2$ and the slurry was applied to both sides of the current collector 102 of 14 μm thickness at a thickness of 72 μm . As a result, the electrode thickness t was 158 μm . One of the edge portions of the shorter side of the current collector 102 was not coated in 1 cm width and a tab 103 (nickel with a thickness of 0.1 mm and a width of 6 mm) was welded.

Paragraph beginning at page 49, line 14 of the specification:

The slurry was applied to only one side by the same method and a single-sided electrode having a thickness of 86 μm was formed by the same method except for the application of the slurry. The single-sided electrode was positioned at the outermost in the stacked electrodes described in Item (3) (101c in FIG. 2).

Paragraph beginning at page 50, line 8 of the specification:

(5) Each positive-electrode tab 103a of the electrode-stacked body made in the above Item (3) was welded to the positive-electrode tab 3 and each negative-electrode tab 103b was welded to the negative-electrode ~~electrode~~ tab 4 through a connection line and then, the electrode-stacked body was set to the battery bottom case 2 and fixed by an insulating tape to laser-weld the overall circumference along the edge A in FIG. 1. Thereafter, a solution made by dissolving LiPF_6 at a concentration of 1 mol/l in a solvent obtained by mixing ethylene carbonate and diethyl carbonate at a weight ratio of 1:1 was poured through a safety-vent hole as electrolyte and the hole was closed by using an aluminum foil having a thickness of 0.1 mm.

Paragraph beginning at page 51, line 7 of the specification:

A positive electrode was formed which was the same as that of the embodiment 2-1 except that slurry was applied to both sides of a current collector 102 at a thickness of 120 μm and the electrode thickness t was set to 260 μm .

Paragraph beginning at page 51, line 11 of the specification:

Then, a negative electrode was obtained by applying negative-electrode mixture slurry same as that of the embodiment 2-1 to both sides of the current collector 102 in a condition different from that of the embodiment 2-1, drying the current collector 102, and then pressing it. Before pressing the current collector 102, 0.2% of NMP was left on the electrode. The electrode density was 1.39 g/cm^3 and the previous evaluation of the capacity of electrode of the electrode

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was 372 mAh/cm³. In the case of the comparative example, the coating area (W1 x W2) of an electrode 101 is 270 x 180 mm² and slurry was applied to both sides of the current collector 102 of 14 μ m thickness at a thickness of 80 μ m. As a result, the electrode thickness t was 174 μ m. The only one side was coated in accordance with the same method and a single-sided electrode of 94 μ m thickness was formed ~~formed~~ by the same method except for the single-sided coating. Other points were the same as the case of the embodiment 2-1.

Paragraph beginning at page 52, line 8 of the specification:

An electrode was formed by the following materials: double-structure active-material particles used as a negative-electrode active material and obtained by covering the surface of graphite particles with amorphous carbon, acetylene black (trade name: DENKA BLACK; made by DENKIKAGAKU KOGYOU Co., Ltd.) used as a conductive material, and a solution used as a binder and obtained by dissolving polyvinylidene fluoride (PVdF) (product name: KF#1100; made by Kureha Chemical Industry Co., Ltd.) in N-methylpyrrolidone. That is, negative electrodes 1 to 7 respectively having a thickness of 100 μ m were formed by applying the polyvinylidene fluoride (PVdF) solution to copper foil having a thickness of 14 μ m serving as a current collector and then, drying the foil at 80 degree Celsius for 15 min, and continuously pressing the foil by a roller press having a radius of curvature of 30 cm while making N-methylpyrrolidone remain.

Paragraph beginning at page 54, line 4 of the specification:

(1) A positive-electrode mixture slurry was obtained by mixing 100 parts by weight of spinel-type LiMn₂O₄ (made by SEIMI CHEMICAL; product No. M063), 10 parts by weight of acetylene black, and 5 parts by weight of polyvinylidene fluoride (PVdF) with 100 parts by weight of N-methylpyrrolidone (NMP). A positive electrode was obtained by applying the slurry to both sides of an aluminum foil having a thickness of 20 μ m serving as a current collector, and drying and pressing the foil. FIG. 6 is an illustration of the electrode. In the case of this embodiment, the coating area (W1 x W2) of the electrode 101 was 268 x 178 mm² and slurry was applied to both sides of the current collector 102 of 20 μ m thickness at a thickness of 128

μm. As a result, the electrode thickness t was 276 μm. One of the edge portions of the shorter side of the current collector 102 was not coated in 1 cm width and a tab 103 (aluminum with a thickness of 0.1 mm and a width of 6 mm) was welded.

Paragraph beginning at page 54, line 22 of the specification:

(2) A negative electrode same as the above negative electrode 1 except for the coating thickness of an electrode was used. Because the shape of the negative electrode is the same as the above positive electrode, the negative electrode is described by referring to FIG. 6. In the case of this embodiment, the coating area (W1 x W2) of the electrode 101 was 270 x 180 mm² and slurry was applied to both sides of the current collector 102 of 14 μm thickness at a thickness of 72 μm. As a result, the electrode thickness t was 158 μm. One of the edge portions of the shorter side of the current collector 102 was not coated in 1 cm width and a tab 103 (nickel with a thickness of 0.1 mm and a width of 6 mm) was welded.

Paragraph beginning at page 55, line 4 of the specification:

Only one side was coated in accordance with the same method and a single-sided electrode of 86 μm thickness was formed ~~formed by~~ the same method except for the single-sided coating. The single-sided electrode was positioned at the outermost in the electrode-stacked body in Item (3) (101c in FIG. 2).

Paragraph beginning at page 55, line 30 of the specification:

(5) Each positive-electrode tab 103a of the electrode-stacked body formed in the above Item (3) was welded to the positive-electrode tab 3 and each negative-electrode tab 103b of it was welded to the ~~negative-electrode~~ negative-electrode tab 4 through a connection line and the electrode-stacked body was set to the bottom case 2 and fixed by an insulating tape to laser-weld the entire circumference along the edge A in FIG. 1. Thereafter, a solution made by dissolving LiPF₆ at a concentration of 1 mol/l in a solvent obtained by mixing ethylene carbonate and diethyl

carbonate at a weight ratio of 1:1 was poured through a safety-vent hole as electrolyte and the hole was closed by using an aluminum foil having a thickness of 0.1 mm.

Paragraph beginning at page 56, line 28 of the specification:

A positive electrode was formed which was the same as that of the embodiment 3-1 except that slurry was applied to both sides of a current collector 102 at a thickness of 130 μm and the electrode thickness t was 280 μm .

Paragraph beginning at page 57, line 3 of the specification:

Then, a negative electrode was used which was the same as the above negative 4 except for the coating thickness of the electrode. The coating area ($W1 \times W2$) of an electrode 101 is $270 \times 180 \text{ mm}^2$ and slurry is applied to both sides of the current collector 102 of 14 μm at a thickness of 70 μm . As a result, the electrode thickness t is 154 μm . T slurry was applied to only one side by the same method and a single-sided electrode having a thickness of 84 μm was formed in accordance with the same method except for the single-sided application of the slurry. Other points were the same as those of the embodiment 3-1.

Paragraph beginning at page 57, line 26 of the specification:

A positive electrode was formed which was the same as that of the embodiment 3-1 except that slurry was applied to both sides of a current collector 102 and the electrode thickness t was 260 μm .

Paragraph beginning at page 57, line 30 of the specification:

Then, a negative electrode was used which was same as the above negative electrode 8 except for the coating thickness of the electrode. In the case of this comparative example, the coating area ($W1 \times W2$) of an electrode 101 was $270 \times 180 \text{ mm}^2$ and slurry was applied to both sides of the current collector 102 of 14 μm thickness at a thickness of 80 μm . As a result, the electrode thickness t was 174 μm . A slurry was applied to only one side by the same method

and a single-sided electrode of 94 μm was formed in accordance with the same method except for the single-sided application of the slurry. Other points were the same as the case of the embodiment 3-1.

Paragraph beginning at page 59, line 24 of the specification:

Three types of negative electrodes 1' to 3' respectively having a thickness of 100 μm were formed by applying the above solution to copper foil of 14 μm thickness with various thickness and then, drying it at 80 degree Celsius for 15 min, and continuously pressing it with a roller press having a radius of curvature of 30 cm.

Paragraph beginning at page 60, line 25 of the specification:

(1) A positive-electrode mixture slurry was obtained by mixing 100 parts by weight of spinel-type LiMn_2O_4 (made by SEIMI CHEMICAL; product No. M063), 10 parts by weight of acetylene black, and 5 parts by weight of polyvinylidene fluoride (PVdF) with 100 parts by weight of N-methylpyrrolidone (NMP). A positive electrode was obtained by applying the slurry to both sides of an aluminum foil having a thickness of 20 μm serving as a current collector, and drying and pressing the foil. FIG. 6 is an illustration of an electrode. In the case of this embodiment, the coating area ($W1 \times W2$) of the electrode 101 was $268 \times 178 \text{ mm}^2$ and slurry was applied to both sides of the current collector 102 of 20 μm thickness at a thickness of 128 μm . As a result, the electrode thickness t was 276 μm . One of the edge portions of the shorter side of the current collector 102 was not coated in 1 cm width and a tab 103 (aluminum with a thickness of 0.1 mm and a width of 6 mm) was welded.

Paragraph beginning at page 61, line 12 of the specification:

(2) A negative electrode was used which was the same as the above negative electrode 2' except for the coating thickness of an electrode. Because the shape of the negative electrode is the same as the above positive electrode, the negative electrode was described by referring to FIG. 6. In the case of this embodiment, the coating area ($W1 \times W2$) of the electrode 101 was

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270x180 mm² and slurry was applied to both sides of the current collector 102 of 14 μm thickness at a thickness of 72 μm . As a result, the electrode thickness t was 158 μm . One of the edge portions of the shorter side of the current collector 102 was not coated in 1 cm width and a tab 103 (nickel with a thickness of 0.1 mm and a width of 6 mm) was welded.

Paragraph beginning at page 61, line 26 of the specification:

Slurry was applied to only one side by the same method and a single-sided electrode having a thickness of 86 μm was formed by the same method except for the single-side application of the slurry. The single-sided electrode was set to the outermost of the stacked electrodes in Item (3) (101c in FIG. 2).

Paragraph beginning at page 62, line 20 of the specification:

(5) Each positive-electrode tab 103a of the electrode-stacked body formed in the above Item (3) was welded to the positive-electrode tab 3 and each negative-electrode tab 103b of it was welded to the negative-electrode tab 4 through a connection line and the electrode-stacked body was set to the bottom case 2 and fixed by an insulating tape to laser-weld the entire circumference along the edge A in FIG. 1. Thereafter, a solution was made by dissolving LiPF₆ at a concentration of 1 mol/l in a solvent obtained by mixing ethylene carbonate and diethyl carbonate at a weight ratio of 1:1, and the solution was poured through a safety-vent hole as electrolyte. The hole was closed by using aluminum foil having a thickness of 0.1 mm.

Paragraph beginning at page 63, line 26 of the specification:

A positive electrode was formed which was the same as that of the embodiment 4-1 except that slurry was applied to both sides of a current collector 102 and the electrode thickness t was 260 μm .

Paragraph beginning at page 63, line 30 of the specification:

Then, a negative electrode same as the above negative electrode 4' except for the coating thickness of the electrode was used. In the case of this comparative example, the coating area ($W1 \times W2$) of an electrode 101 was $270 \times 180 \text{ mm}^2$ and slurry was applied to both sides of the current collector 102 of $14 \text{ }\mu\text{m}$ thickness at a thickness of $80 \text{ }\mu\text{m}$. As a result, the electrode thickness t was $174 \text{ }\mu\text{m}$. A slurry was applied to only one side by the same method and a single-sided electrode of $94 \text{ }\mu\text{m}$ was formed in accordance with the same method except for the single-side application of the slurry. Other points were the same as the case of the embodiment 4-1.

Paragraph beginning at page 68, line 23 of the specification:

(1) A positive-electrode mixture slurry was obtained by mixing 100 parts by weight of LiCo_2O_4 , 8 parts by weight of acetylene black, and 3 parts by weight of polyvinylidene fluoride (PVdF) with 100 parts by weight of N-methylpyrrolidone (NMP). A positive electrode was obtained by applying the slurry to both sides of aluminum foil having a thickness of $20 \text{ }\mu\text{m}$ serving as a current collector, and drying and pressing the foil. FIG. 6 is an illustration of an electrode. In the case of this embodiment, the coating area ($W1 \times W2$) of the electrode 101 is $268 \times 178 \text{ mm}^2$ and slurry was applied to both sides of the current collector 102 of $20 \text{ }\mu\text{m}$ thickness at a thickness of $105 \text{ }\mu\text{m}$. As a result, the electrode thickness t is $230 \text{ }\mu\text{m}$. One of the edge portions of the shorter side of the current collector 102 was not coated in 1 cm width and a tab 103 (aluminum with a thickness of 0.1 mm and a width of 6 mm) was welded.

Paragraph beginning at page 69, line 9 of the specification:

(2) A negative-electrode mixture slurry was obtained by mixing 100 parts by weight of graphitized mesocarbon microbeads (MCMB, made by OSAKA GAS CHEMICAL Co., Ltd., product No. 6-28) and 10 parts by weight of PVdF with 90 parts by weight of NMP. A negative electrode was obtained by applying the slurry to both sides of copper foil having a thickness of $14 \text{ }\mu\text{m}$ serving as a current collector, drying the foil and then pressing the foil. Because the shape of the electrode is the same as that of the above-described positive electrode, the negative electrode is described below by referring to FIG. 6. In the case of this embodiment, the coating

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area (W1 X W2) of the electrode 101 was 270x180 mm² and the slurry was applied to both sides of the current collector 102 of 14 μm thickness at a thickness of 110 μm . As a result, the electrode thickness t was 234 μm . One of the edge portions of the shorter side of the current collector 102 was not coated in 1 cm width and a tab 103 (nickel with a thickness of 0.1 mm and a width of 6 mm) was welded.

Paragraph beginning at page 69, line 28 of the specification:

Slurry was applied to only one side in accordance with the same method and a single-sided electrode having a thickness of 124 μm was in accordance with the same method formed except for the single-side application of the slurry. The single-sided electrode was set to the outermost of the stacked electrodes in Item (3) (101c in FIG. 2).

Paragraph beginning at page 74, line 7 of the specification:

The separator is sufficiently resilient and has a capacity ~~retension~~retention rate equal to those of the embodiments 5-1 and 5-2 after 10 cycles pass. However, because the separator has a large thickness, the capacity was lower than those of the embodiments 5-1 and 5-2.

Paragraph beginning at page 77, line 16 of the specification:

Then, the second separator is more minutely described below. The second separator is a micro-porous film having a pore diameter of 5 μm or less or preferably having a pore diameter of 2 μm or less and having a porosity of 25% or more or preferably having a porosity of 30% or more. A pore diameter can be observed by an electron microscope. The above micro-porous film can use a micro-porous film generally marketed for a lithium ion battery. The second separator is used to compensate a disadvantage that a slight short circuit easily occurs when the battery is manufactured or charged or discharged because the separator has a comparatively large pore diameter and a high porosity. Therefore, a case in which the pore diameter of the second separator exceeds 5 μm is not preferable because it is impossible to compensate the above disadvantage. A case in which the porosity is less than 25% is not preferable because an

electrolyte cannot be sufficiently kept or the internal resistance rises. Furthermore, because the thickness of the second separator is 0.05 mm or less, it is possible to use a separator having a thickness of not more than 5 μm and not more than 30 μm . This is because it is difficult to manufacture the separator if the thickness is too small or the internal resistance tends to rise if the thickness is too large.

Paragraph beginning at page 79, line 20 of the specification:

(1) A positive-electrode mixture slurry was obtained by mixing 100 parts by weight of LiCo_2O_4 , 8 parts by weight of acetylene black, and 3 parts by weight of polyvinylidene fluoride (PVdF) with 100 parts by weight of N-methylpyrrolidone (NMP). A positive electrode was obtained by applying the slurry to both sides of aluminum foil having a thickness of 20 μm serving as a current collector, and drying and pressing the foil. FIG. 6 is an illustration of an electrode. In the case of this embodiment, the coating area ($W1 \times W2$) of the electrode 101 is $268 \times 178 \text{ mm}^2$ and slurry was applied to both sides of the current collector 102 of 20 μm thickness at a thickness of 95 μm . As a result, the electrode thickness t was 210 μm . One of the edge portions of the shorter side of the current collector 102 was not coated in 1 cm width and a tab 103 (aluminum with a thickness of 0.1 mm and a width of 6 mm) was welded.

Paragraph beginning at page 80, line 6 of the specification:

(2) A negative-electrode mixture slurry was obtained by mixing 100 parts by weight of graphitized mesocarbon microbeads (MCMB, made by OSAKA GAS CHEMICAL Co., Ltd., product No. 6-28) and 10 parts by weight of PVdF with 90 parts by weight of NMP. A negative electrode was obtained by applying the slurry to both sides of copper foil having a thickness of 14 μm serving as a current collector, drying the foil and then pressing the foil. Because the shape of the electrode is the same as that of the above-described positive electrode, the negative electrode is described below by referring to FIG. 6. In the case of this embodiment, the coating area ($W1 \times W2$) of the electrode 101 was $270 \times 180 \text{ mm}^2$ and the slurry was applied to both sides of the current collector 102 of 14 μm thickness at a thickness of 105 μm . As a result, the electrode thickness t was 224 μm . One of the edge portions of the shorter side of the current

collector 102 was not coated in 1 cm width and a tab 103 (nickel with a thickness of 0.1 mm and a width of 6 mm) was welded.

Paragraph beginning at page 80, line 26 of the specification:

Slurry was applied to only one side in accordance with the same method and a single-sided electrode having a thickness of 119 μm was formed in accordance with the same method except for the single-sided application of the slurry. The single-sided electrode is set to the outermost of the electrode-stacked body in Item (3) (101c in FIG. 2).

Paragraph beginning at page 82, line 4 of the specification:

(5) Each positive-electrode tab 103a of the electrode-stacked body formed in the above Item (3) was welded to the positive-electrode tab 3 and each negative-electrode tab 103b of it was welded to the negative-electrode tab 4 through a connection line and the electrode-stacked body was set to the bottom case 2 and fixed by an insulating tape to laser-weld the entire circumference of the corner A in FIG. 1. Thereafter, a solution made by dissolving LiPF_6 at a concentration of 1 mol/l in a solvent obtained by mixing ethylene carbonate and diethyl carbonate at a weight ratio of 1:1 was poured through a safety-vent hole as an electrolyte and the upper case was closed by using aluminum foil having a thickness of 0.1 mm. The total of five batteries were formed as described above.

Paragraph beginning at page 83, line 26 of the specification:

Five batteries were formed similarly to the case of the embodiment 6-1 except for using only the polyethylene-polypropylene non-woven fabric same as the first separator of the embodiment 6-1 shown in Table 5 as a first separator without using a second separator and change the number of stacked electrodes to 8 positive electrodes (thickness of either-side electrode layer was 105 μm) and 9 negative electrodes (including two single-sided electrodes and thickness of either-side electrode layer was 110 μm). The battery was charged by a constant-current/constant-voltage charging for 8 hours, in which the battery was charged up to

4.1 V by a current of 5 A and then charged by a constant voltage of 4.1 V. Then, the batteries were discharged up to 2.5 V by a constant current of 10 A. The discharge capacities of three batteries ranged between 23.1 and 23.3 Ah but the capacities of two remaining batteries were 19.5 Ah and 14.3 Ah and a slight short circuit was found. Because the comparative example 6-1 did not use a second separator, the electrode packing rate was improved compared with the case of the embodiment 6-1 but a slight short circuit easily occurred through the initial capacity was high.

Paragraph beginning at page 88, line 4 of the specification:

(1) A positive-electrode mixture slurry was obtained by mixing 100 parts by weight of LiCO_2O_4 , 8 parts by weight of acetylene black, and 3 parts by weight of polyvinylidene fluoride (PVdF) with 100 parts by weight of N-methylpyrrolidone (NMP). A positive electrode was obtained by applying the slurry to both sides of aluminum foil having a thickness of 20 μm serving as a current collector, and drying and pressing the foil. FIG. 6 is an illustration of an electrode. In the case of this embodiment, the coating area ($W1 \times W2$) of the electrode 101 was $268 \times 178 \text{ mm}^2$ and slurry was applied to both sides of the current collector 102 of 20 μm thickness at a thickness of 95 μm . As a result, the electrode thickness t was 210 μm . One of the edge portions of the shorter side of the current collector 102 was not coated in 1 cm width and a tab 103 (aluminum with a thickness of 0.1 mm and a width of 6 mm) was welded.

Paragraph beginning at page 88, line 21 of the specification:

(2) A negative-electrode mixture slurry was obtained by mixing 100 parts by weight of graphitized mesocarbon microbeads (MCMB, made by OSAKA GAS CHEMICAL Co., Ltd., product No. 6-28) and 10 parts by weight of PVdF with 90 parts by weight of NMP. A negative electrode was obtained by applying the slurry to both sides of copper foil having a thickness of 14 μm serving as a current collector, drying the foil and then pressing the foil. Because the shape of the electrode is the same as that of the above-described positive electrode, the negative electrode is described below by referring to FIG. 6. In the case of this embodiment, the coating area ($W1 \times W2$) of the electrode 101 is $270 \times 180 \text{ mm}^2$ and the slurry was applied to both sides of

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the current collector 102 of 14 μm thickness at a thickness of 105 μm . As a result, the electrode thickness t was 224 μm . One of the edge portions of the shorter side of the current collector 102 was not coated in 1 cm width and a tab 103 (aluminum with a thickness of 0.1 mm and a width of 6 mm) was welded.

Paragraph beginning at page 89, line 9 of the specification:

Slurry was applied to only one side in accordance with the same method and a single-sided electrode having a thickness of 119 μm was formed in accordance with the same method except for the single-sided application of the slurry. The single-sided electrode was set to the outermost of the electrode-stacked body in Item (3) (101c in FIG. 2).

Paragraph beginning at page 89, line 16 of the specification:

(3) A positive electrode unit 111a, negative electrode unit 111b, and single-sided negative electrode unit 111c were formed by bonding a separator 104 obtained by laminating polyethylene-polypropylene non-woven fabric of 272x180 mm² (thickness of 87 μm) and a polypropylene micro-porous film (thickness of 25 μm) to a positive electrode 101a and negative electrodes 101b and 101c at the positional relation shown in FIGS. 12A to 12C. Each electrode was bonded with the polyethylene-polypropylene non-woven fabric side of the separator 104. Specifically, the separator 104 and electrodes (positive electrode 101a and negative electrodes 101b and 101c) were stacked in the order at a predetermined position and heated from the electrode side by an iron at approximately 140 degree Celsius to bond them. After bonding them, the separator 104 was observed by removing it from some of the electrode units 111a, 111b, and 111c. As a result, the state of surface pores of the separator 104 was hardly changed from the state before the separator 104 was bonded. An electrode-stacked body was formed by alternately stacking eight positive-electrode units 111a, seven negative-electrode units 111b, one single-sided negative-electrode unit 111c, one single-sided negative electrode 101c not bonded with the separator 104, and the separator 104 as shown in FIG. 10.

Paragraph beginning at page 90, line 20 of the specification:

(5) Each positive-electrode tab 103a of the electrode-stacked body formed in the above Item (3) was welded to the positive-electrode tab 3 and each negative-electrode tab 103b of it was welded to the negative-electrode tab 4 through a connection line and the electrode-stacked body was set to the bottom case 2 and fixed by an insulating tape to laser-weld the entire circumference of the corner A in FIG. 1. Thereafter, a solution was made by dissolving LiPF_6 at a concentration of 1 mol/l in a solvent obtained by mixing ethylene carbonate and diethyl carbonate at a weight ratio of 1:1. The solution was poured through a safety-vent hole as an electrolyte and the upper case was closed by aluminum foil having a thickness of 0.1 mm. The total of five batteries were formed.

Paragraph beginning at page 96, line 13 of the specification:

The method of the present invention for controlling a secondary battery for a energy storage system can be applied to each cell or the cells selected according to a necessity in a module formed by combining a plurality of single cells or in a battery system formed by combining the modules. In this case, as a control mode, it is possible to use ~~conventionally~~ conventionally proposed cell basis control or module basis control together with cell by cell control of the present invention. Further, it is possible to control a module or battery system by utilizing the fluctuation information regarding each of different cells. For example, when each of the cells shows similar operation-characteristic, simultaneous control can be performed for each of the modules or whole of the battery system.

Paragraph beginning at page 98, line 5 of the specification:

(1) Positive-electrode mixture slurry was obtained by mixing 100 parts by weight of spinel-type LiMn_2O_4 (made by SEIMI CHEMICAL; product No. M063), 10 parts by weight of acetylene black, and 5 parts by weight of polyvinylidene fluoride (PVdF) with 100 parts by weight of N-methylpyrrolidone (NMP). A positive electrode was obtained by applying the slurry to both sides of aluminum foil having a thickness of 20 μm and drying and pressing the foil. FIG. 15 is an illustration of an electrode. In the case of this embodiment, the coating area (W1 X W2) of an electrode 1101 was $133 \times 198 \text{ mm}^2$ and slurry was applied to both sides of 20- μm

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aluminum foil 1102 at a thickness of 120 μm . As a result, the electrode thickness was 260 μm . One of the edge portions of the current collector extending along the arrow W2 and having a width of 1 cm was not coated with the electrode, and a tab 1103 (aluminum having a thickness of 0.1 mm and a width of 6 mm) was welded thereto.

Paragraph beginning at page 98, line 23 of the specification:

(2) Negative-electrode mixture slurry was obtained by mixing 100 parts by weight of graphitized mesocarbon microbeads (MCMB: made by OSAKA GAS CHEMICAL Co., Ltd.; product No. 628) and 10 parts by weight of PVdF with 90 parts by weight of NMP. A negative electrode was obtained by applying the slurry to both sides of copper foil having a thickness of 14 μm and drying and pressing the foil. Because the shape of the negative electrode is the same as the above positive electrode, the negative electrode is described by referring to FIG. 15. In the case of this embodiment, the coating area (W1 X W2) of the electrode 1101 was 135x200 mm^2 and the slurry was applied to both sides of the copper foil 1102 at a thickness of 80 μm . As a result, the electrode thickness t is 174 μm . One of the edge portions of the current collector extending along the arrow W2 and having a width of 1 cm is not coated with the electrode, and a tab 1103 (nickel having a thickness of 0.1 mm and a width of 6 mm) is welded thereto.

Paragraph beginning at page 99, line 10 of the specification:

Slurry was applied to only one side by the same method and a single-sided electrode having a thickness of 94 μm was formed by the same method other than the side. The single-sided electrode is set to the outermost of the electrode-stacked body in the following Item (3) (1101n' in FIG. 17).

Paragraph beginning at page 101, line 29 of the specification:

(1) Positive-electrode mixture slurry was obtained by mixing 100 parts by weight of spinel-type LiMn_2O_4 (made by SEIMI CHEMICAL; product No. M063), 10 parts by weight of

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acetylene black, and 5 parts by weight of PVdF with 100 parts by weight of NMP. A positive electrode was obtained by applying the slurry to both sides of aluminum foil having a thickness of 20 μm and drying and pressing the foil. FIG. 18 is an illustration of an electrode. In the case of this embodiment, the coating area ($W1 \times W2$) of an electrode 1201 was $258 \times 168 \text{ mm}^2$ and slurry was applied to both sides of 20- μm aluminum foil 1202 at a thickness of 120 μm . As a result, the electrode thickness t was 260 μm . Both of the edge portions and the central portion of the current collector in the view of the longitudinal direction of the collector was not coated with the electrode in the width of 1 cm, and a tabs 1203a, 1203b, and 1203c (aluminum having a thickness of 0.1 mm and a width of 4 mm) was welded thereto.

Paragraph beginning at page 102, line 16 of the specification:

A measuring electrode having measuring electrodes 1204a, 1204b, and 1204c was formed in order to measure the fluctuation of internal voltages. The electrode was formed by welding a 3 mm-square expand metal (aluminum) having a thickness of 50 μm to one end of a slender piece of stainless-steel foil having a width of 3 mm and a thickness of 10 μm , attaching the expand metal to the surface of a positive electrode in a battery, bonding the stainless-steel foil to the positive electrode while insulating it from the positive electrode, and positioning the other end of the piece of the foil to protrude beyond an edge of the positive electrode to form a terminal.

Paragraph beginning at page 102, line 28 of the specification:

(2) Negative-electrode mixture slurry was obtained by mixing 100 parts by weight of graphitized mesocarbon microbeads (MCMB) and 10 parts by weight of PVdF with 90 parts by weight of NMP. A negative electrode was obtained by applying the slurry to both sides of a copper foil having a thickness of 14 μm and drying and pressing the foil. Because the shape of the negative electrode is the same as the above positive electrode, the negative electrode is described by referring to FIG. 18. In the case of this embodiment, the coating area ($W1 \times W2$) of the electrode 1201 is $260 \times 170 \text{ mm}^2$ and the slurry was applied to both sides of the copper foil 1202 of 14 μm at a thickness of 80 μm . As a result, the electrode thickness t was 174 μm .

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Both of the edge portions and the central portion of the current collector in the view of the longitudinal direction of the collector was not coated with the electrode in the width of 1 cm, and a tabs 1203a', 1203b', and 1203c' (copper having a thickness of 0.1 mm and a width of 4 mm) was welded thereto.

Paragraph beginning at page 103, line 16 of the specification:

To measure the fluctuation of internal voltages, measuring electrodes having protruded ends as measuring electrodes 1204a', 1204b', and 1204c' were formed, in the same manner as in the positive electrode, by welding a 3 mm-square expand metal (copper) having a thickness of 50 μm to an end of a slender piece of stainless-steel foil having a width of 3 mm and a thickness of 10 μm .

Paragraph beginning at page 103, line 23 of the specification:

Furthermore, slurry was applied to only one side by the same method and a single-sided electrode having a thickness of 94 μm was formed by the same method other than the single-sided application of the slurry. The single-sided electrode was set to the outermost of the electrode-stacked body stated in the following Item (3) (1201n' in FIG. 19).

Paragraph beginning at page 103, line 30 of the specification:

(3) An electrode-stacked body was formed by alternately stacking ten positive electrodes 1201p and eleven negative electrodes (nine both-sided electrodes 1201n and two single-sided electrodes 1201n') obtained in the above Item (1) with a separator 1205 (made by TONEN TAPIRUSU Co., Ltd.; made of porous polyethylene) held between each of the electrode as shown in FIG. 19. A separator made of polypropylene non-woven fabric having a thickness of 100 μm was set between electrodes provided with internal-potential measuring terminals. The positive electrodes and negative electrodes were stacked so that their terminals protrude in mutually opposite direction.